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A MONITORING SYSTEM FOR SYNOPTIC OBSERVATIONS OF JOVIAN AND SOLAR DECAMETER-WAVE RADIO EMISSIONS

BY

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

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ABSTRACT

This report describes a simple decameter-wave monitoring system designed to provide synoptic observations of the sporadic radio emission from Jupiter. The network is composed of five stations located around the world so as to provide continuous coverage of Jupiter with identical instruments. A pair of two-element lobe-sweeping interferometers operating at 16.7 and 22.2 MHz comprise each station. To illustrate the performance of the system, results of observations at the Goddard Space Flight Center site during the 1965 apparition of Jupiter are presented.

INTRODUCTION

Due to the sporadic nature of the decameter-wave radio emission from Jupiter, most studies of the properties of the emission have required observations obtained over long periods of time in order to be statistically adequate. The problem is further complicated since a major portion of the observatories studying Jupiter have been clustered near a single longitude region on the earth. Hence, much of the data available for study are confined to a limited number of hours every twenty-four hours. To perform statistical studies of the emission properties, such as correlation with the periods of Jupiter's moons or with solar activity, continuous observations are needed. Simultaneous observations with identical, widely spaced instruments are required, for example, to study the time structure of the radio bursts and to sort ionospheric scintillations from scintillations which may be caused by the ionosphere of Jupiter and the interplanetary medium. This report describes a network of simple stations which was designed with a view toward meeting these needs.

The Jupiter Monitor Network provides continuous, homogeneous observations of Jupiter at 16.7 and 22.2 MHz with reasonable sensitivity. By operating each station 24 hours a day, the network can also be used profitably to observe solar radio bursts at decametric wavelengths and to study ionospheric absorption and scintillations. The locations of the five sites which comprise the network are listed in Table 1.

Station	Longitude	Latitude
Goddard Space Flight Center	76°50'W	39°01'N
Clark Lake Radio Observatory	116°17'W	33°20'W
Kauai, Hawaii	159°40'W	22°07'N
Carnarvon, Australia	113°43'E	24°53'S
Grand Canary Island, Spain	15°36'W	27°44'N

TABLE 1. STATION LOCATIONS

Except for the Clark Lake installation, all stations are located at NASA sites and utilize established NASA technical and logistic support facilities.

SYSTEM DESCRIPTION

Each station consists of a pair of antennas (the antennas for 16.7 and 22.2 MHz are five-element Yagis mounted on the same boom and drive) separated by a 2000-ft. east-west baseline. As illustrated in Figure 1, the antennas are mounted equatorially on 35-ft. guyed telephone poles with motorized hour angle drive systems. Since the declination of Jupiter changes very slowly, declination adjustments are made manually every few months.

Antenna pointing is controlled by a simple electro-mechanical computer. This device causes the antennas to slew east to pick up Jupiter when it attains an hour angle of -6 hours, tracking Jupiter for twelve hours thereafter. Then it moves the antennas to the position of the sun and tracks the sun, providing the hour angle of the sun is between -6 hours and +6 hours. If neither Jupiter nor the sun is available, the antennas slew to the meridian and remain fixed.

As shown in the block diagram in Figure 2, the radiometer systems operate in a time-sharing mode in which they act as lobe-sweeping radiometers for 75% of each basic 1/20 second cycle. For the remaining time, switching circuits connect the receiver to act as a riometer on first one antenna and then the other. In the riometer mode, the effective temperature of a noise generator is controlled to be equal to the effective temperature of the antenna at the receiver input terminals by a switch and phase sensitive detector system. The riometer for each antenna is in operation for 1/4 of the time. The antenna switch is transferred from the antenna to the noise generator 1/8 of the time, leaving 3/4 of the time with both antennas connected permitting operation in the lobe-sweeping radiometer mode.

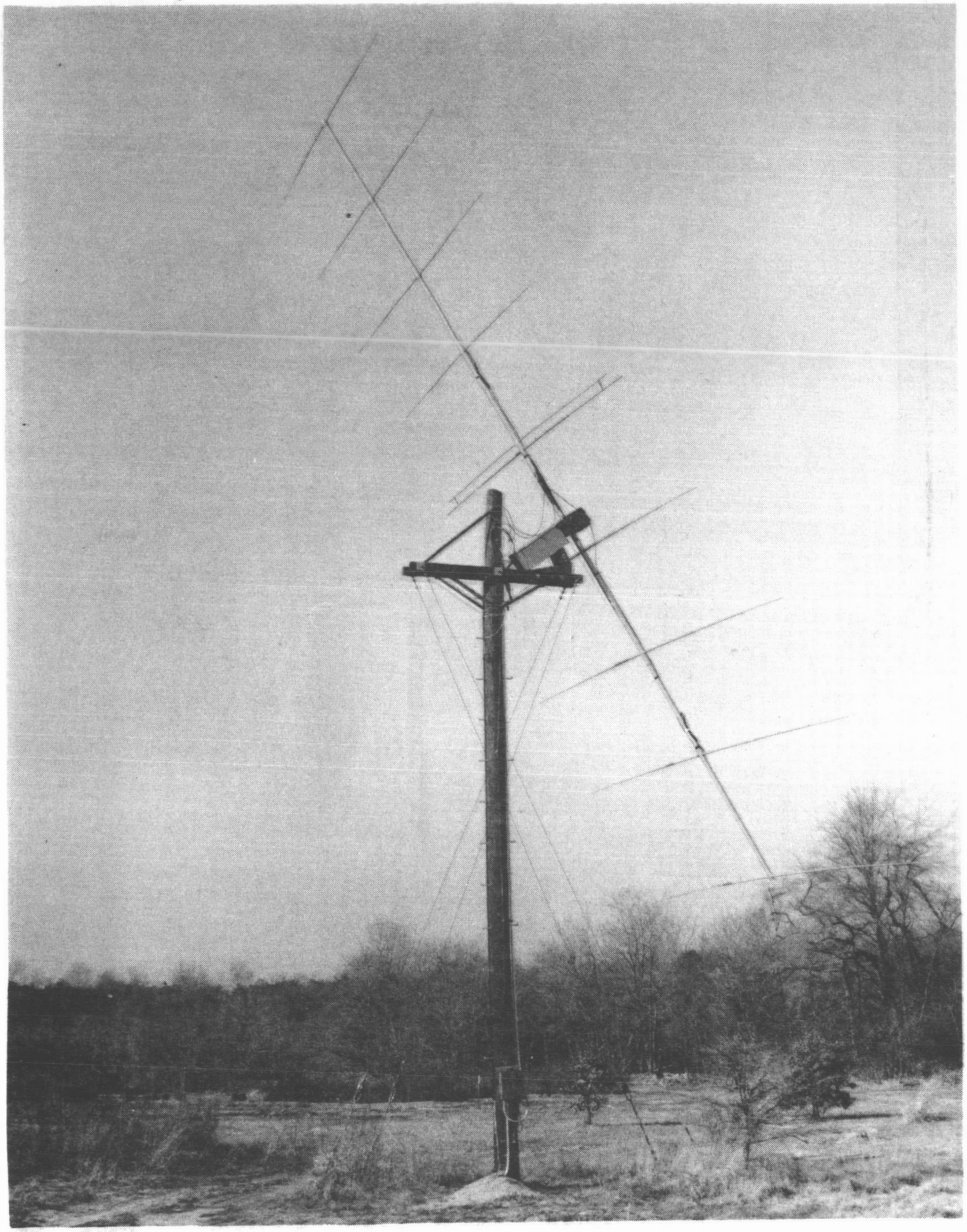

Figure 1 - Dual-frequency, equatorially mounted, Jupiter Monitor Network antenna.

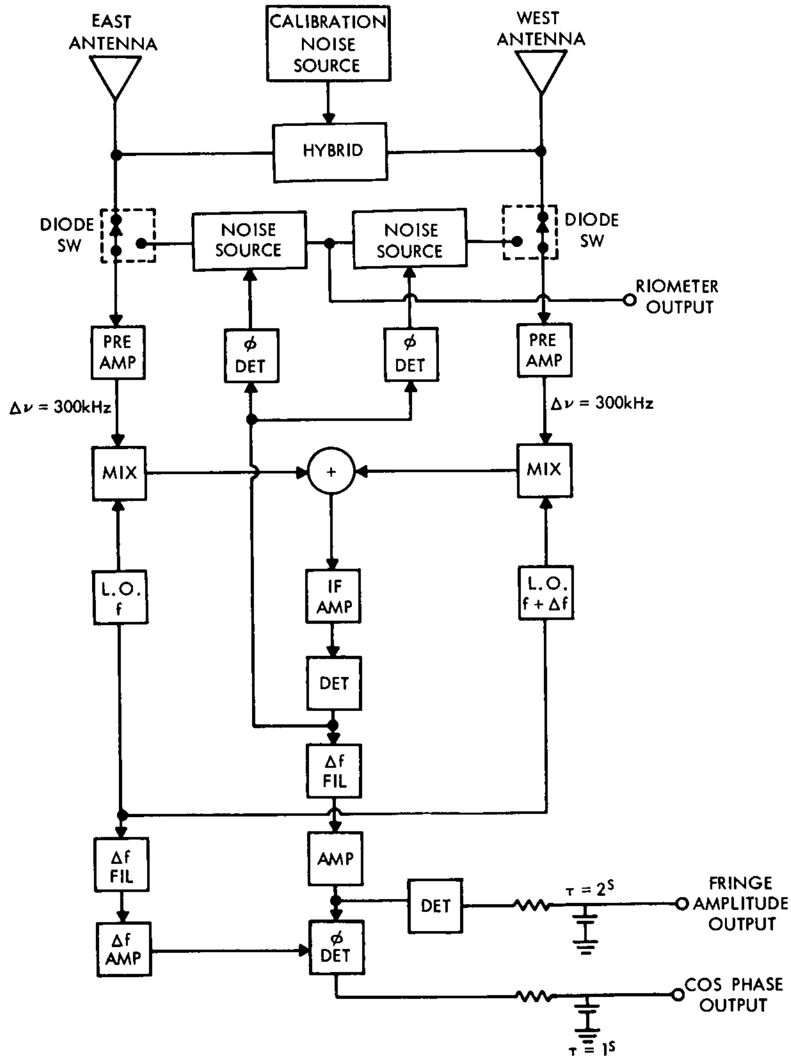

Figure 2 - Block diagram of Jupiter Monitor radiometer system.

In the lobe-sweeping radiometer, signals from each antenna are individually pre-amplified and mixed with signals from individual local oscillators at frequencies which differ by a small amount, Δf. (The difference frequency, Δf, is nominally 1 kHz.) The mixer outputs are then added, amplified, and squared by square-law detection. DC, noise, and an audio-frequency component at the difference frequency result. The amplitude of the audio component is detected and recorded as "fringe amplitude". The audio component is also compared to the phase difference between the two local oscillators in a phase sensitive detector producing a "cosine phase" output which is proportional to the product of the intensity and the phase difference of the incoming signal at the two antennas. Thus, the "fringe amplitude" output is a measure of the flux of incoming Jupiter or solar radiation, and the "cosine phase" output varies sinusoidally as the angle of arrival to the interferometer baseline changes due to the earth's rotation.

Hourly calibrations of the system are provided by an automatic calibration unit. Noise from a separate noise generator in the calibration unit is added to the signals from each antenna through a hybrid at the receiver input. The generator output is automatically stepped through four noise levels, and during a portion of one step a 90° phase shift is inserted in the lobe-sweeping radiometer phase detector reference signal to calibrate instrumental phase shift.

DATA

The three radiometer outputs at each frequency are displayed on paper strip charts by a six-channel recorder. A data system which converts the six analog outputs to digital information on magnetic tape in a format convenient for computer processing is under test at the Goddard site and is described in Appendix I.

Typical sections of data are illustrated in Figure 3 and 4 which show a transit of Cassiopeia A and Jupiter, respectively. From the Cassiopeia record, assuming the flux density from Cassiopeia to be 4.5×10^{-22} $W/M^2/Hz$ at 20 MHz (Bazelian et al, 1963) and correcting for the fact that the antennas were directed 40^o south of the source, one can estimate the system sensitivity to be approximately 10^{-22} $W/M^2/Hz$.

Continuous observations began at the Goddard site in November, 1965, with the remaining stations in the network becoming operational later in 1966. Jupiter measurements at the Goddard station have been compiled for the period from November, 1965, through February, 1966, and the results of that analysis follow. All measurements were made with the antennas set to the declination of Jupiter and held fixed on the local meridian. Hence, the analysis was confined to periods between three hours before transit to three hours after transit - the approximate half-power beam width of the Yagi antennas. Further criteria required to identify observed emission to be of Jovian origin were an identifiable interferometer lobe pattern on the radiometer phase channel with an amplitude of three times the rms system noise and freedom from radio frequency interference. Useful observations were obtained on a total of 104 days at 16.7 MHz and 88 days at 22.2 MHz with an average interference-free observing period of 5.3 hours per day at 16.7 MHz and 1.9 hours per day at 22.2 MHz. Depending upon the degree to which the above identification criteria were met, events of Jupiter activity were classified as (1) "possible", (2) "probable", or (3) "definite". Only activity in ID classes 2 and 3 was used in the analysis to be discussed below.

Data were reduced in the following manner. Each six-hour period centered on local meridian transit of Jupiter was divided into 5-minute intervals. Each interval was inspected for occurrence of interference and, if interference-free, for evidence of Jupiter

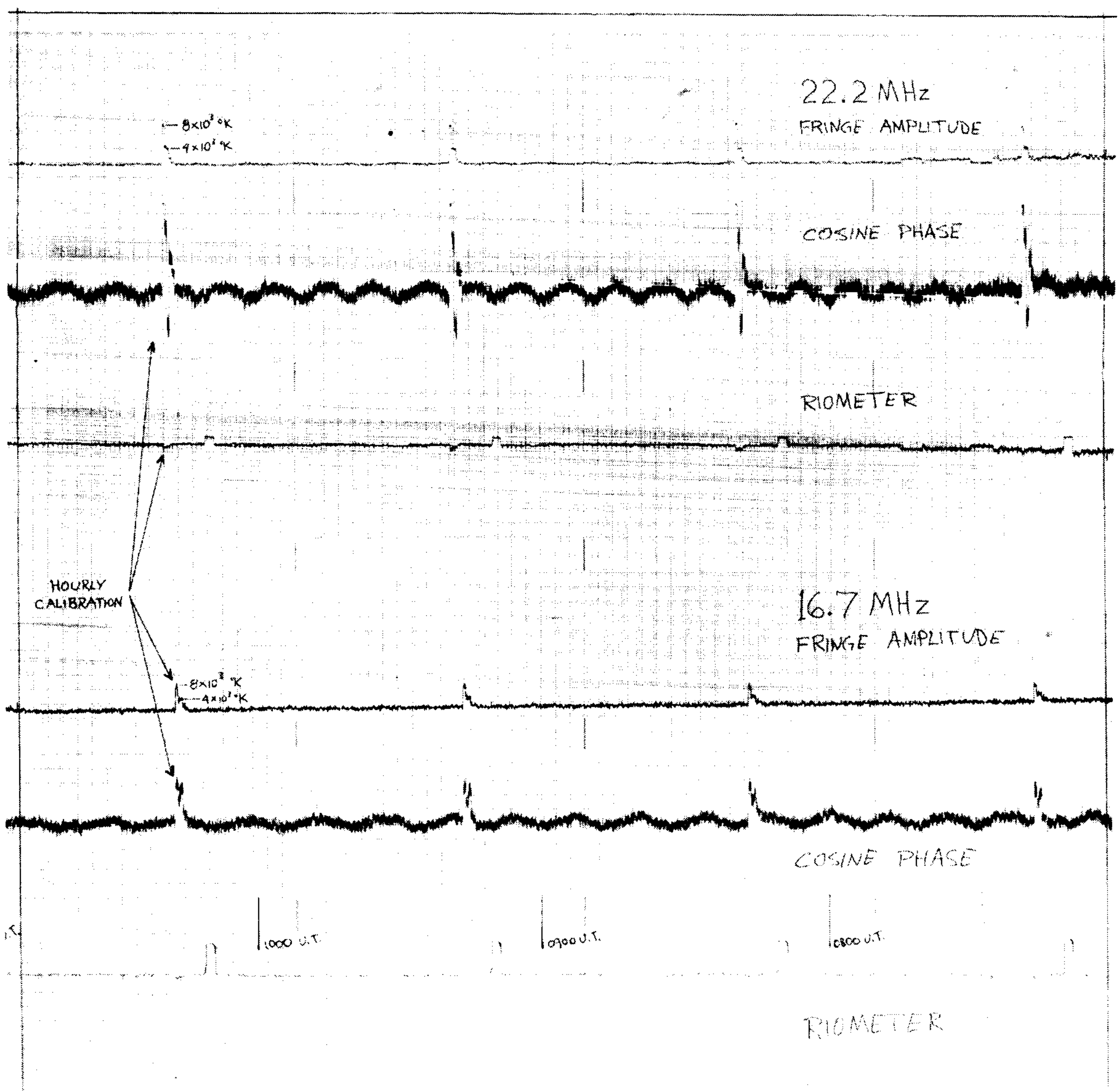

Figure 3 - Section of record showing the passage of Cassiopeia A through the interferometer pattern. The antennas were set on the meridian at a declination approximately 40° south of the declination of the source.

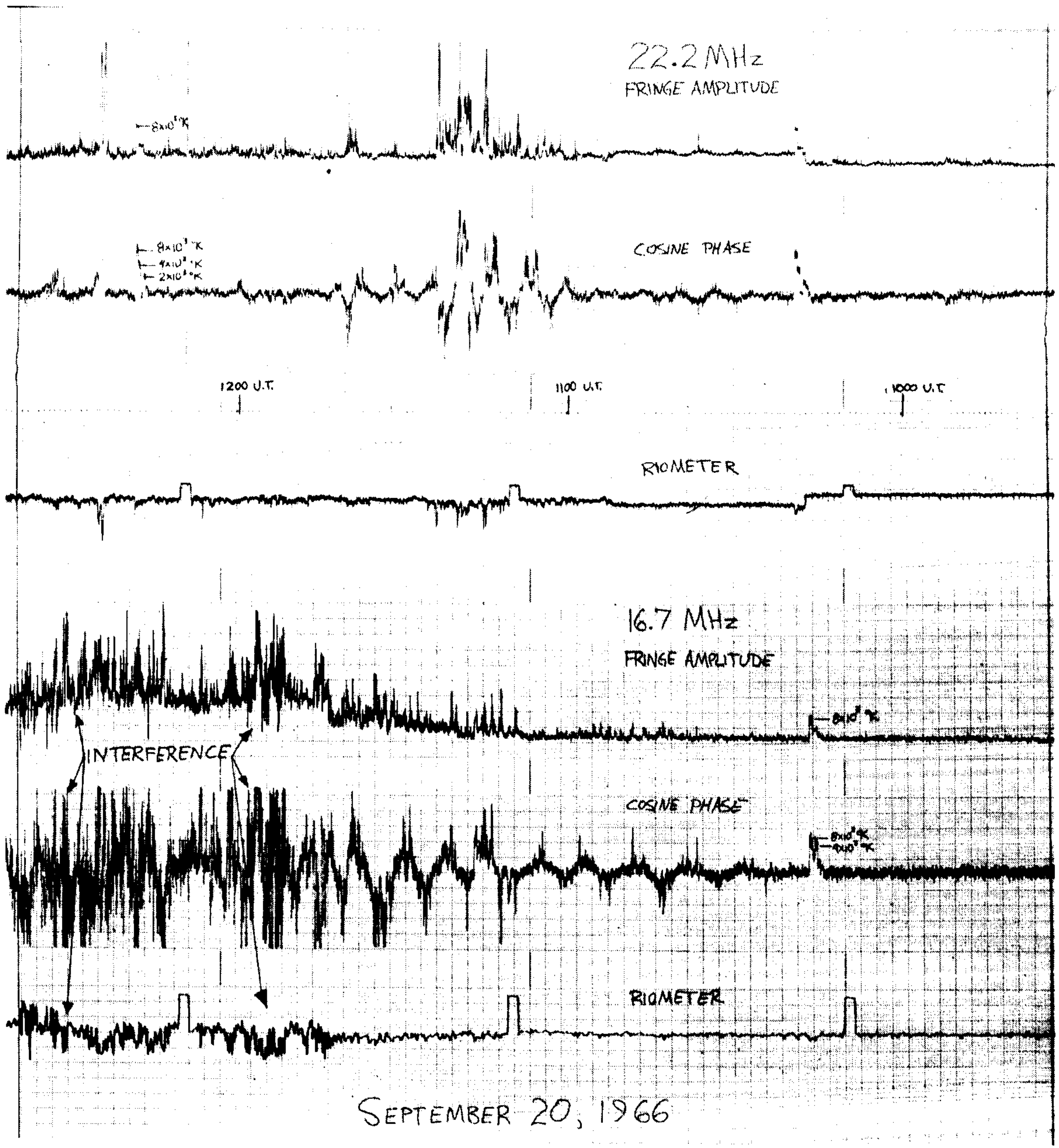

Figure 4 - Sample record showing Jupiter activity at both frequencies. Strong 16.7 MHz interference obscures the Jupiter emission after local sunrise.

activity. Those noise events which could be classed as definite or probable Jupiter activity were scaled to give the average and peak antenna temperatures for each 5-minute interval. Further information such as an estimate of the number of bursts and the time character of the emission in each 5-minute interval was also noted.

Appendix II of this report gives a catalog of the Goddard Jupiter observations at both frequencies for the period November 11, 1965 through February 28, 1966. The observations also are shown as a function of the System III (1957.0) central meridian longitude of Jupiter and the departure of Jupiter's satellite Io from superior geocentric conjunction in Figure 5. The thin lines show the relative positions of λIII and Io for all times when useable observations of Jupiter could have been obtained, and the heavy solid lines indicate the times when activity was observed to occur. Notice that the thin lines are not evenly distributed over the graph, indicating that certain combinations of λIII and the position of Io have been observed repeatedly whereas for other combinations observations are inadequate or missing entirely. This points up the need for continuous observations of Jupiter. A statistically adequate series of measurements cannot be obtained from a single site in a reasonably short period of time.

The more conventional histogram plots of occurrence probability versus λIII and the position of Io are presented for our data in Figure 6. Occurrence probability is simply defined as the number of 5-minute intervals for a given 5° longitude interval in which Jupiter activity was observed divided by the number of 5-minute intervals of good observing time for the same 5° longitude interval. At 22.2 MHz the three λIII "source" regions are clearly discernible; at 16.7 MHz the main and late sources (regions A and C) tend to merge into a single broad region extending from $\lambda\text{III} \approx 210^{\circ}$ to $\lambda\text{III} \approx 360^{\circ}$. The λIII histograms illustrate an interesting result

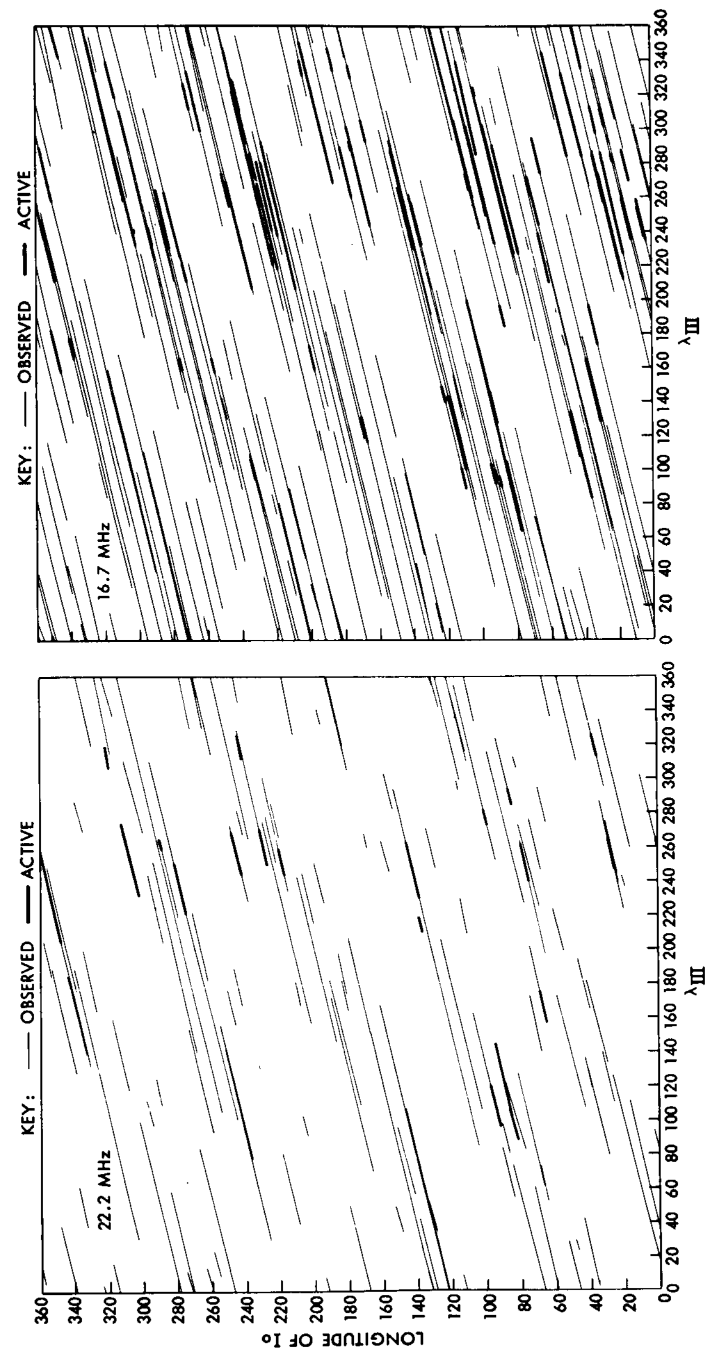

Figure 5 - Goddard Jupiter observations for the period November 11, 1965, to February 28, 1966, as a function of the System III (1957.0) central meridian longitude of Jupiter (λIII) and the departure of Jupiter's satellite Io from superior geocentric conjunction (longitude of Io). Periods when useful observations could be obtained are indicated by the thin lines; periods when Jupiter activity was detected are shown by the heavy lines.

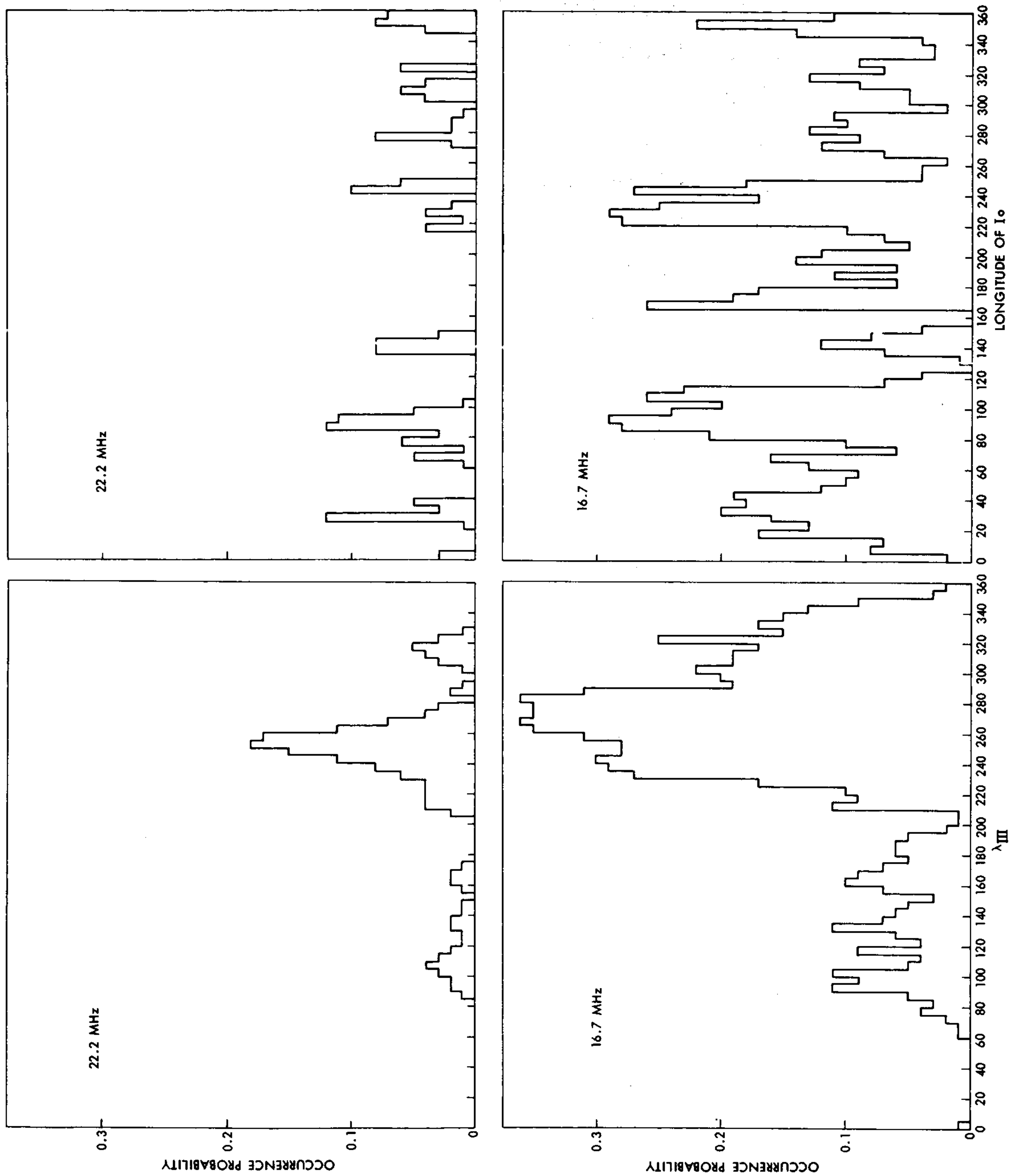

Figure 6 - Histogram plots of Jupiter activity occurrence probability versus the System III (1957.0) central meridian longitude of Jupiter (λIII) and the departure of Jupiter's satellite Io from superior geocentric conjunction (longitude of Io).

regarding the radio rotation rate of Jupiter. If the System III rotation period lengthed by approximately 1 second in 1961 as reported by the Yale and Florida workers (Douglas and Smith, 1963; Smith et al, 1965), then features on the histograms such as the null region between the early and main sources or the peak of the main source should advance in λIII (1957.0) by about 10° per year. On this basis, our 22.2 MHz data for the 1965 apparition should show the main source peak to be near $\lambda III = 270^{\circ}$. The peak occurs instead at $\lambda III \approx 255^{\circ}$. The main source peak at 16.7 MHz is similarly located the order of 10° below the position predicted on the basis of a 1 second change in the rotation period. The occurrence probability minimum between the early and main source regions was located near $\lambda III = 180^{\circ}$ in 1961 and, on the basis of a 10° shift per year, the minimum would be expected to fall near 220° in 1965. The Goddard station data in Figure 6 indicate that this feature must occur below 205°. In other words, a change in the rotation rate in the opposite direction to that reported by the Yale and Florida workers must have occurred between 1963 and 1965. Dulk (1965a) has reached a similar conclusion from analysis of HAO data. Gulkis and Carr (1966) have presented evidence that the apparent rotation period drifts cyclically about a constant mean period with a drift period of 11.9 years. Our results would be qualitatively consistent with that hypothesis.

Although there are histogram peaks when Io is near 90° and 240° from superior geocentric conjunction, they do not dominate as one might have expected from the results of other workers (Dulk, 1965b; Lebo et al, 1965). At 22.2 MHz this discrepancy may be attributable to the rather poor observing statistics and, at 16.7 MHz, to the further fact that the Io control is not as strong at the lower frequencies.

Figure 7 is a slightly different form of histogram in which we have plotted the dependence of occurrence probability on the System III longitude of Io. One can see at once that the

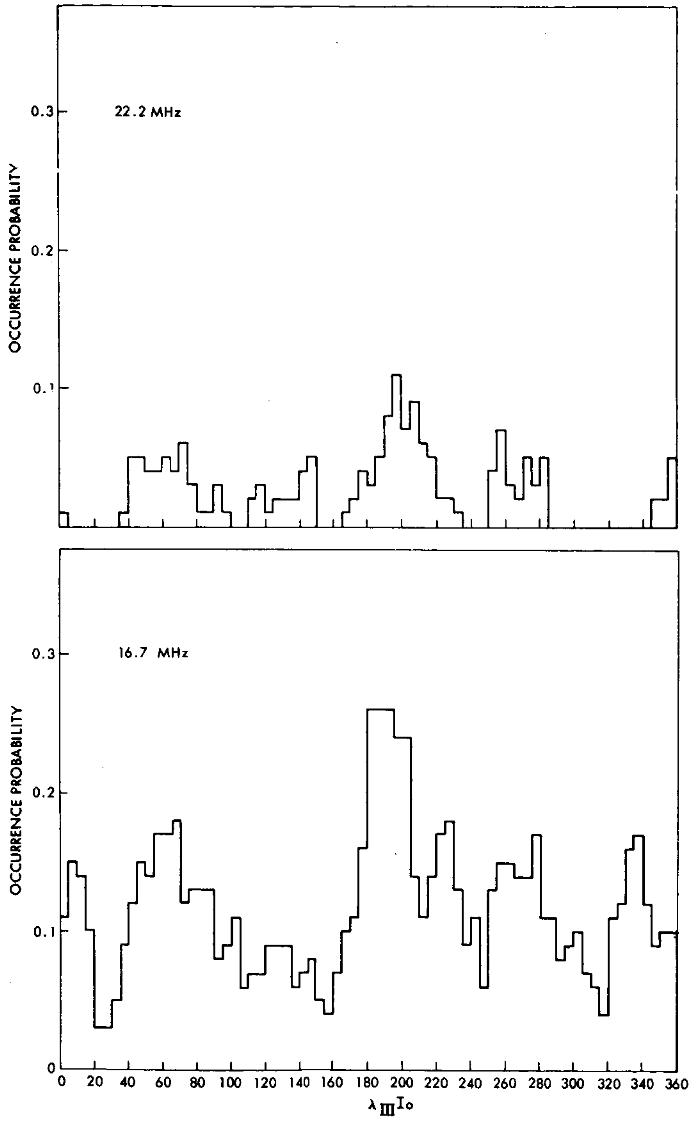

Figure 7 - Histogram plot of occurrence probability as a function of the System III (1957.0) longitude Io.

probability of occurrence is a maximum when Io is near $190^o < \lambda III < 200^o$, the longitude of Jupiter's magnetic pole. In other words, the probability of detecting emission is greatest when Io is at the position in its orbit where its north magnetic latitude is greatest. At both frequencies the occurrence probability has a minimum nearly 180^o away from the maximum at $\lambda III \approx 20^o$.

ACKNOWLEDGEMENTS

The Jupiter Monitor radiometer system was designed and built under the direction of Dr. J. N. Douglas of the University of Texas and Mr. Richard Boynton of Space Electronics, Inc. The data system described in Appendix I was designed and built under the direction of Mr. William Olden of the Advanced Development Division. The data catalog in Appendix II was compiled by Mrs. H. H. Malitson from data scaled by Mr. W. Williams. These contributions are all gratefully acknowledged.

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Lebo, G. R., Smith, A. G., Carr, T. D., Science 148, 1742 (1965).

Gulkis, S., and Carr, T. D., Science 154, 257 (1966).

Smith, A. G., Lebo, G. R., Six, N. F., Carr, T. D., Bollagen, H., May, J., and Levy, J., Ap. J. 141, 457 (1965).

APPENDIX I

The data produced when all five stations are fully operational will be sufficiently voluminous as to make completely manual reduction procedures impractical. It will be desireable, furthermore, to compare portions of the data with similar measurements obtained from satellite experiments such as the Radio Astronomy Explorer. For these reasons, a data recording system has been designed which will place the data on a tape suitable for direct computer processing. All stations are expected to have the new data system by early 1967.

The three analog outputs of each radiometer system are first fed to six integrating digital voltmeters where they are integrated over a sample period of either ½ or 10 sec. To determine the sample period to be used, the instantaneous value of the "cosine phase" output and "fringe amplitude" output of each radiometer is compared with its average value of the previous five seconds using a differential amplifier. If the respective difference voltage is greater than a preset amount, the high speed rate is initiated. Low speed sampling is initiated when the values do not differ by more than the preset amount.

Four characters from each of the six integrating digital voltmeters, ten characters from a time standard decoder and two ID characters are formed into a data frame by a switching matrix. Each 36 character frame is recorded on magnetic tape at the end of each sample period. At the end of 32 frames, an interfile gap is generated to maintain IBM compatibility.

Calibration of the unit is done each day by the station operator. All integrating voltmeters are set to a known preset voltage, and the values placed on tape are read out for a "nixie" display so the operator can make a quick check of the system operation.

APPENDIX II

Jupiter observations at the Goddard Space Flight Center station for the 1965 apparition are listed in the catalog to follow. Data are presented in terms of U.T. days. The column labeled "Observing Period" lists the intervals during each day when Jupiter was within three hours of meridian transit, when the receiving equipment was known to be working properly, and when no interference signals were known to be present. The "Observing Period", therefore, is the time when useful observations of Jupiter could have been recorded if Jupiter had been active. The column labeled "Jupiter Activity" lists the intervals during each observing period when Jupiter activity was observed with an intensity greater than $\sim 3 \times 10^{-22}$ W/M^2/Hz and which could be classified as (2) probable or (3) certain. The column labeled Ta_{max} gives the average value of the maximum effective antenna temperature at the input to the receiver during each five-minute interval of activity. T_a is in units of $10^{3\,o}$K. To get the actual antenna temperature, one must correct for cable losses (approximately 15 db at 16.7 MHz and 18 db at 22.2 MHz) and mismatch between the antenna and receiver. Exceptions to the above definitions are cited in the "Notes" column.

November 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
11	0450-1055	0755-0925	3	5.5		0450-1045	0810-0905	2	2.9	
12	0445-1050	0545-0730	3	4.4		0710-0955				
		1020-1035	2	3.1		1010-1040				
13	0450-1045					0735-1045				
14	0405-1045	0405-0425	2		1	0345-0435				
		0435-0500	2	3.1		0745-1040				
		0640-0800	2	2.8						
15	0430-0435					0610-1035				
	0450-1035									
16	0430-1035					0430-1035				
17	0425-1035					0425-0500 0705-1035				
18	0420-0540					0705-1025				
	0545-0600									
	0650-0700									
	0805-1035	0925-0940	2	1.4						
		1005-1035	2	2.3						

November 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
19	0415-1020	0610-0755	3	4.0		0710-1020				
20	0415-0550					0810-1015				
	0555-0705									
	0905-1015									
21	0405-0500					0405-0505				
	0805-1010	0800-0940	2	4.2		0710-0735 0745-1005	0745-0800	2	3.4	
22	0405-0510					0505-0615				
	0645-0700					0650-1000				
	0935-1000									
23	0405-1000	0810-0950	3	5.5		0410-1000	0810-0905	3	2.8	
24	0355-0600	0415-0530	3	5.6		0435-0525				
	0805-1000					0710-1000				
25	0350-0710					0710-0955				
	0725-0955									
26	0345-0950	0535-0700	3	5.9		0710-0950	0740-0805	2	3.0	
		0715-0745	2	3.6						
		0815-0900	3	5.4						
27	0340-0455					0730-0945				

November 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
	0505-0945									
28	0335-0520					0710-0940				
	0525-0940	0710-0900	3	3.7						
29	0330-0355					0555-0710				
	0410-0455					0720-0935				
	0505-0935	0505-0550	2	2.5						
30	0325-0720	0520-0635	2	5.8						
	0725-1000									

December 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	$T_{a\,max}$	Notes	Observing Period	Jupiter Activity	ID Class	$T_{a\,max}$	Notes
01	0320-0550									
	0605-0855					0715-0930				
	0905-0930									
02	0315-0430									
	0440-0805					0710-0920				
	0815-0920									
03	0315-0920					0710-0920				
04	0230-0915	0230-0530	3	3.4		0230-0305	0230-0305	2		1
05	0305-0915	0355-0525	3	4.0		0750-0915				
06	0305-0555	0310-0500	3	4.2		0345-0505	0410-0455	3	3.4	
	0605-0900					0610-0905				
07	0305-0900					0610-0900				
08	0250-0525									
	0540-0550									
	0615-0700									
	0815-0855					0745-0855				

December 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
10	0240-0400									
	0605-0845	0645-0840	3	4.5		0655-0845	0735-0805	3	3.0	
11	0240-0510	0340-0435	2	4.3		0730-0900				
	0610-0845									
12	0230-0835					0750-0835				
13	0230-0500									
	0530-0835					0530-0835				
14	0225-0830	0635-0640	2	5.9		0635-0645 0655-0715 0720-0830	0635-0715	2	3.9	
15	0220-0825	0410-0425	2	3.3		0220-0405				
		0610-0635	3	3.6		0710-0825				
16	0220-0820	0255-0315	2	6.7		0710-0820				
17	0210-0820					0610-0815				
18	0405-0500	0420-0500	2	7.0						
	0510-0820									
19	0250-0425					0640-0805				
	0520-0800									

December 1965

Date	16.7 MHz Observing Period	Jupiter Activity	ID Class	Ta max	Notes	22.2 MHz Observing Period	Jupiter Activity	ID Class	Ta max	Notes
20	0155-0800	0455-0650	3	4.6		0545-0800	0545-0620	2	2.8	
		0725-0800	2	3.8						
21	0150-0755					0645-0755				
22	0145-0825	0650-0825	3	3.8	1	0630-0815	0735-0800	3	4.0	1
23	0140-0745	0245-0445	3	4.5		0710-0745				
24	0140-0450									
	0505-0745					0640-0745				
25	0135-0745					0610-0740				
26	0130-0735					0555-0735				
27	0205-0305									
	0320-0340									
	0345-0530									
	0535-0625									
	0630-0730					0650-0730				
28	0120-0400	0230-0320	3	8.0		0200-0305	0210-0305	2	2.5	
	0505-0725					0645-0725				
29	0115-0215									

December 1965

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
	0335-0420									
	0430-0720	0530-0550	2	6.4		0610-0720				
30	0105-0110					0120-0200	0120-0150	3	4.0	
	0150-0310					0210-0240				
	0315-0320	0315-0525	3	5.9		0610-0715				
	0325-0600	0550-0600	3	4.6						
	0620-0710									
31	0105-0715	0125-0155	2	2.9		0610-0715				

January 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
01	0105-0700	0105-0130	2	2.4		0425-0445	0425-0445	2	1.8	
		0230-0250	2	1.6		0625-0705				
02	0105-0335					0640-0705				
	0350-0700									
03	0055-0600					0210-0505				
	0640-0700					0610-0705				
04	0050-0345	0235-0320	3	3.2						
	0350-0400	0350-0400	2	4.6						
	0415-0555	0425-0445	2	2.8						
	0605-0655					0640-0655				
05	0045-0055									
	0105-0310	0105-0125	2	2.4						
	0315-0500	0430-0455	2	3.2						
	0605-0650					0610-0650				
06	0040-0350					0040-0235				
	0405-0425					0310-0505	0420-0455	3	3.8	
	0505-0510					0535-0645	0535-0550	3	4.9	
	0520-0530									

January 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
	0535-0545									
	0615-0645									
07	0035-0640	0035-0115	2	5.5		0245-0350 0610-0640				
08	0115-0640	0545-0600	2	9.1						
		0610-0630	2	5.0						
09	0025-0110					0135-0250	0135-0250	3	6.8	
	0135-0630	0135-0500	3	>9.2	2	0340-0405	0340-0405	3	6.4	2
10	0025-0440	0410-0440	2	2.2						
	0450-0630	0450-0455	2	5.3		0545-0630				
11	0020-0405	0110-0155	3	4.5		0020-0205				
	0445-0625	0315-0400	2	4.2						
12	0015-0620					0610-0620				
13	0010-0615	0510-0600	3	2.4						
15	0000-0600	0235-0300	2		3					
	2355-2400									
16	0000-0555	0440-0520	2		3	0510-0600				

January 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
	2350-2400					2350-2400				
17	0000-0555					0000-0005				
	2350-2400					0110-0555				
18	0000-0030					0110-0205				
	0110-0555	0205-0230	2		3	0310-0555	0310-0450	3		3
	2345-2400	0320-0425	3		3					
19	0000-0550	0005-0145	3		3	0030-0050				
	2340-2400	0235-0300	2		3	0210-0335				
20	0000-0545	0240-0345	2		3	0210-0305 2335-2400				
21	0020-0420	0105-0400	3		3	0000-0005				
	0430-0500					0335-0405	0335-0405	2		3
	0520-0540					0510-0540				
22	0025-0050									
	0125-0345	0250-0345	2		3					
	0415-0535	0415-0450	3		3	0310-0450	0335-0450	3		3
	2330-2400					2330-2400				

January 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
23	0000-0300					0000-0305				
	0310-0350									
	0405-0535									
	2320-2400									
24	0000-0525					0110-0525				
25	0005-0525									
26	0120-0510	0210-0235	2		3					
		0310-0325	2		3					
	2320-2400	2320-2400	2		3					
27	0000-0520									
	2305-2400									
28	0005-0510	0005-0035	2		3	0210-0405	0225-0250	3		3
	2345-2400	0125-0350	3		3					
29	0005-0330					0310-0505				
	0335-0345									
	0350-0500									
30	2305-2400									
31	0005-0040									
	0050-0455									

February 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
01	0005-0335									
	0350-0455									
07	2225-2400									
08	0000-0425									
	2305-2355									
09	0030-0420									
	2230-2400									
10	0000-0140									
	0205-0415					2205-2235				
11	0000-0010					0140-0215				
	0025-0410					0325-0410				
	2330-2400					2205-2245				
12	0000-0005					0300-0410				
	0025-0100	0025-0100	2		3					
	0125-0410									
	2330-2400					2200-2220				
13	0000-0010					0325-0405				

February 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
	0050-0115									
	0130-0405									
	2325-2340					2155-2220				
	2355-2400									
14	0000-0005					0125-0220				
	0025-0205	0025-0120	3		3	0305-0320				
	0210-0400					2150-2220				
15	0005-0355					0325-0355				
	2355-2400					2145-2240				
16	0000-0015					0305-0350				
	0030-0055					2145-2255				
	0130-0135									
	0145-0350									

February 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
17	0005-0035					0305-0350				
	0115-0350					2145-2240				
18	0045-0340					0145-0340				
						2135-2255				
19	0015-0340									
	2130-2145					2200-2335				
	2350-2400									
20	0000-0030									
	0050-0335									
	2325-2400					2355-2400				
21	0000-0335	0255-0335	2	3.1		0000-0050				
	2315-2400	2330-2400	3	8.8		0255-0335				
22	0000-0330	0000-0055	3							
	2245-2400	2245-2400	3	4.6		2325-2400	2325-2400	2	6.2	
23	0000-0325	0000-0235	3			0245-0325				
	2240-2300					2305-2400				
	2315-2400									

February 1966

	16.7 MHz					22.2 MHz				
Date	Observing Period	Jupiter Activity	ID Class	Ta max	Notes	Observing Period	Jupiter Activity	ID Class	Ta max	Notes
24	0000-0320					0000-0320				
	2115-2200					2115-2315				
	2245-2320					2335-2400				
25	0000-0125					0000-0320				
	0155-0320									
	2345-2400									
26	0000-0315	0135-0230	2	2.4						
	2345-2400					2105-2140				
27	0000-0310					0245-0310				
	2335-2400					2100-2315				
28	0000-0305	0055-0130	2	3.9						

NOTES

1. Clearly identifiable Jupiter storm observed beyond the nominal observing period cut-off of H.A. = $\pm 3^h$.

2. Unusually intense, long duration storm.

3. Ta not scaled due to minor recorder problem.